Prediction of the Vertical Motion Induced by Present-day Glacial Isostasy and Memory of Recent and Thousand Year Time Scale Mass Changes: Antarctic Peninsula and Patagonia as Case Studies

by

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Several high-quality land-based gravity and GPS station measurements now demonstrate the ability to monitor long-term variations driven by isostatic rebound with signatures at a microGals) and mm(s) per year level. This fact offers hope that new geophysical problems now might be amenable to testing by such measuring systems. Here we examine glacial-hydrological loading of the continents by smaller late-Holocene ice mass variation in Patagonia and the Antarctic Peninsula. This resultant isostasy is, indeed, analogous to the 40 to 100 kyr. time scales characteristic of Pleistocene glacial cycles. However, a number of new issues arise. These are related to the smaller load wavelength, lower characteristic viscosity of the mantle located beneath non-Cratonic crust/lithosphere and a more recent and contemporaneous temporal mass behavior. A comprehensive study of Patagonian glacier change by Aniya et al. (1997) has definitively determined a 20th Century mass wasting at a rate of about 5.8 +- 2.7 Giga tons / yr since 1944. In the Antarctic Peninsula region, recent ice shelf demise and a general susceptibility strong precipitation and temperature fluctuations suggest that total glacial mass fluctuations will have a rich time spectrum and may involve total present-day mass imbalance at rates that are larger than in southern Patagonia. We consider loading cycles from 300 to 5000 years in duration. The predicted present-day vertical crustal motion response (and it's spatial variability) due to realistic loading/unloading of Patagonia and the Antarctic Peninsula, offers a rich response spectra. These are largely dependent on the assumed mantle viscosity. For viscosity's higher than 2.0 x 10^20 Pa sec, the predicted rates are small for these late Holocene load events (< 1.5 - 2.0 mm/yr). For mantle viscosity below 1.0 x 10^20 Pa sec, however, the rates increase with decreasing viscosity and the most recent phases of glacier change are promoted in overall influence. Near 1.0 x 10^19 Pa sec vertical isostatic motion motion may exceed 10 mm/yr. A simple analytical representation for the last 1000 years of glacial change that allows the some basic principles to be deciphered in terms of "observed" mass balance. We also present maps of the predicted uplift/subsidence rates and attempt to assess the merits and deficits of the assumed load histories.